KEEPING THE LIGHTS ON IN AN ALL-ELECTRIC FUTURE

BIDIRECTIOAL EV'S AND CHARGING

CONNECTING THE DOTS FOR A SUSTAINABLE FUTURE

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What IS "Bidirectional Charging"?

<u>Bidirectional charging is:</u>

- A process by which a bidirectional capable EV works with a bidirectional charger / inverter

- Charger / inverter charges and discharges the car's battery electrical current from the car to operate electrical devices in a home or building or through the home to the grid.

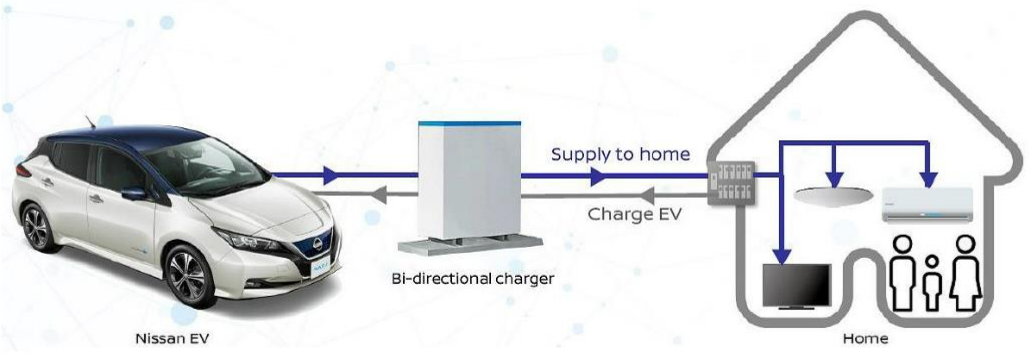
- Provides unparalleled resilience for homes AND for the grid.

- EV is able to provide 3 days + power

"V2X"

V2X = ["VEHICLE TO EVERYTHING"]

- V2L = "VEHICLE TO LOAD"
  - Powers loads in a mobile manner



- V2B = "VEHICLE TO BUILDING"
  - Powers essential loads in a home or building

- V2G = "VEHICLE TO GRID"
  - Exports energy through the home or building to the grid

TYPES OF BIDIRECTIONAL CHARGING

DC POWER BIDIRECTIONAL – from the EV battery

- DC bidirectionality exports the DC energy to a site-based inverter, which converts the DC energy to AC for use in the home, or export to the grid
- Virtually that same manner as a stationary battery + inverter system does.
- OEM sets limit as to how much export they will allow.
- Dcbel technology charges EV "DC direct" from your solar to EV, and only one inversion required to AC for home or to the grid

TYPES OF BIDIRECTIONAL CHARGING

AC POWER BIDIRECTIONALITY:

- Requires a modification of the EV's onboard inverter.

- OEMs are developing mostly proprietary AC systems to allow this functionality to a select group of EV's, mostly in the higher end of their ecosystems.

- AC systems are more expensive to develop, and this may explain the OEM's desire to keep the system proprietary, and within its own closed ecosystem.

- Proprietary systems have a resilience and monetary payback benefit for the owner, but do not maximize the benefits society as a whole.

DCBEL R16 – FIRST "UNIVERSAL" HOME BASED DC BIDIRETIONAL CHARGER CERTIFIED IN THE USA

- EV AGNOSTIC
- POWERFUL 15.2 Kw SOLAR INVERTER
- 2 PORT (BIDIRECTIONAL) CHARGER:
  - LEVEL 2 AC
  - LEVEL "2.5" DC BIDIRECTIONAL CHARGER (1 mile / minute charging)
- STATIONARY BATTERY MANAGEMENT : (LG CHEM PARTNERSHIP)
- HOME ENERGY MANAGEMENT SYSTEM
  - OPTIMIZES AND PRIORITIZES ENERGY FLOW IN THE HOME
- SUNSPEC CERTITIFIED FOR GRID EXPORT AND INTEROPERABILIY (required for Ca. Rule 21)

MANY OTHER BIDIRECTIONAL CHARGER MANUFACTURURES ON THE WAY!

BIDIRECTIONAL **HOME** CHARGERS AND SYSTEMS (EV Agnostic)

- DCBEL (North American Certified) Also a Solar inverter, HEMS, grid interactive

- WALLBOX (UK Certified, USA in 2024)

- EMPORIA (2024)

- Enphase (2024)

- DELTA (CURRENTLY USED ONLY WITH FORD F-150)

- FERMATA (NO DATE)

- SOLAR EDGE (2024)

AC BIDIRECTIONAL (PROPRIETARY) CHARGERS

- FORD-F150 LIGHTNING (V2L and DC V2X)
- GM SILVERADO (no date)
- STELLANTIS RAM 1500 REV
- TESLA (2025)
- LUCID (AC V2L)
- FISKER (AC V2L, also partnering with Wallbox for DC V2X)
- HYUNDAI (AC V2L)
- KIA (AC V2L)
- VOLKSWAGEN (coming soon, DC V2X, unknown if it will be proprietary)
- Mercedes (US timing unknown)
- BMW (PILOTS)
- HONDA (PILOTS)
- BYD ATTO 3 (N/A IN US, AC V2L)
- MG ZS (N/A IN US, AC V2L)
- KIA EV6 (AC V2L)
- KIA EV9 (AC V2L, V2G)
- GENESIS GV 69 (AC V2L)
- HYUNDAI IONIQ 5 (AC V2L)
- HYUNDAI IONIQ 6 (AC V2L)



BIDIRECTIONAL CAPABLE EV's

EV's with DC V2X EXPORT

- NISSAN LEAF (SINCE 2011)
- MITSUBISHI HIGHLANDER HYBRID
- VOLVO EX90
- POLESTAR 3
- VOLVO EX30 (2024)
- VOLVO XC 40 RECHARGE
- VOLVO C40 RECHARGE
- KIA SOUL (UP TO 2019)
- ALL Tesla EV's by 2025
- ALL GM EV's by 2026
- **Ford – Honda – BMW "CHARGESCAPE"** partnership for grid services

PROPRIETARY BIDIRECTIONAL SYSTEMS / EV's

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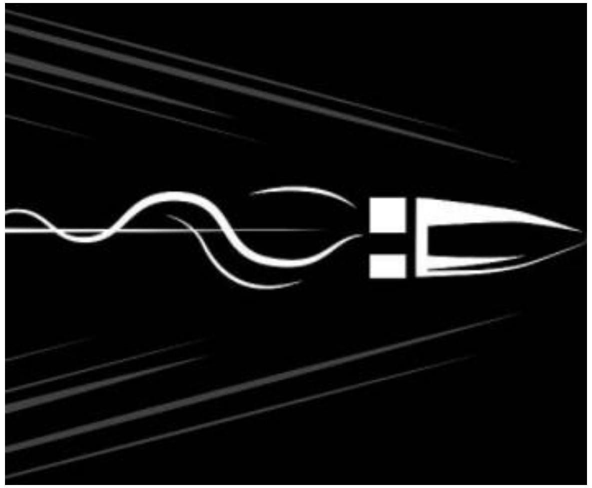
PLATFORM INTEROPERABILITY

- FOR MAXIMUM SOCIETAL BENEFIT, ALL EV's and BIDIRECTIONAL CHARGERS SHOULD BE INTEROPERABLE

- ANY EV CAN DISCHARGE FROM MUTIPLE LOCATIONS

- CREATES A "MOBILE MICROGRID" OF ENERGY

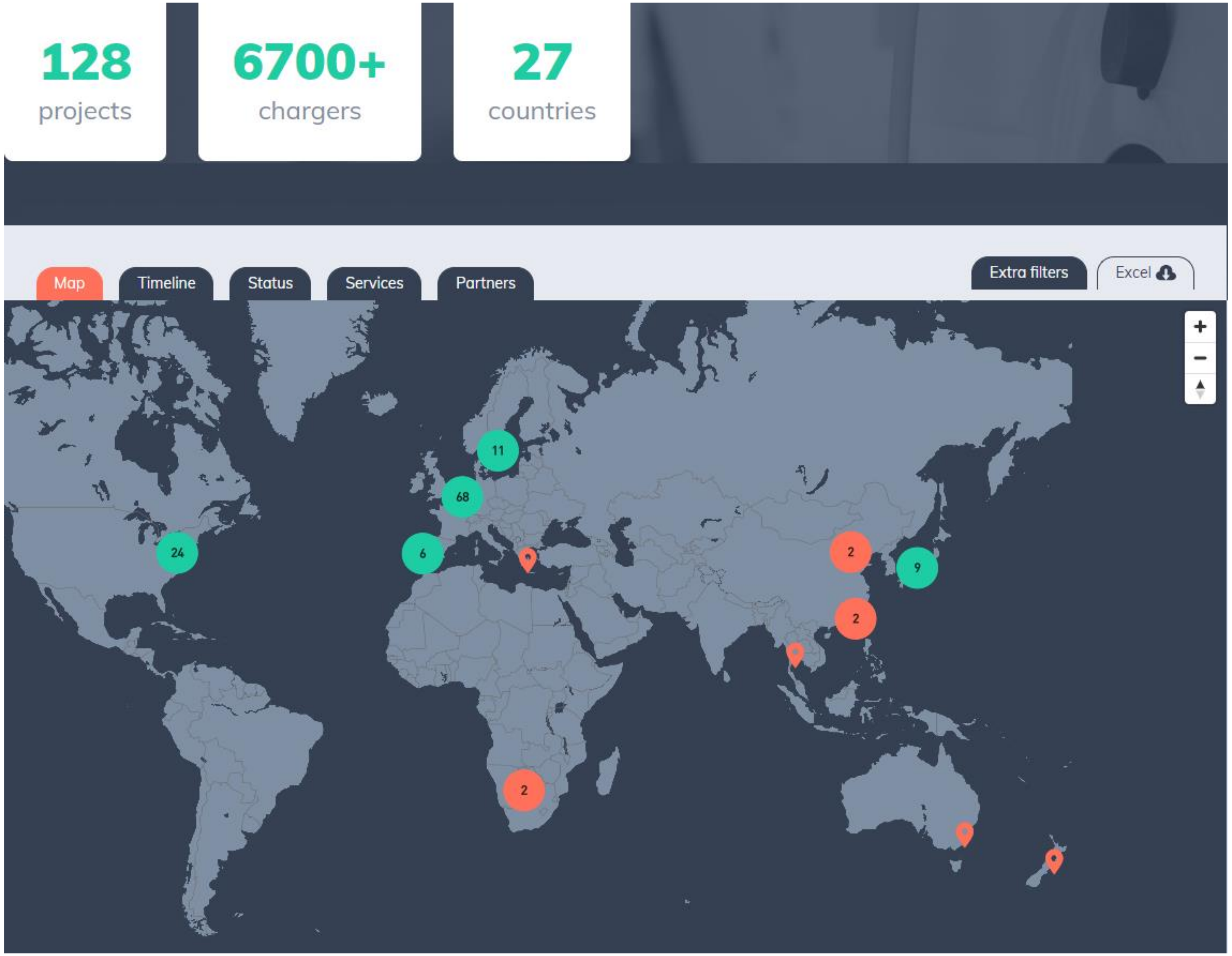


- V2X represents a **"SILVER BULLET"** for Sustainability, Decarbonizing the Built Environment, Transportation, and Energy Sectors simultaneously

GLOBAL V2G PROJECTS: https://www.v2g-hub.com/

PROVEN TECHNOLOGY WITH OVER 120 PROJECTS

- After many years of technological development, experimentation, policy reform and standardization initiatives, the V2G market is now ready to enter a fast-paced, multi-year expansion period.
- More on the history of bidirectional charging can be found in this [recently published white paper]()



GRID INTEROPERABILITY

- The grid communication standards are now complete for V2G; through the ISO 15118 interoperable CCS DC bidirectional charging standard.

- Standardization initiatives will ensure interoperability.

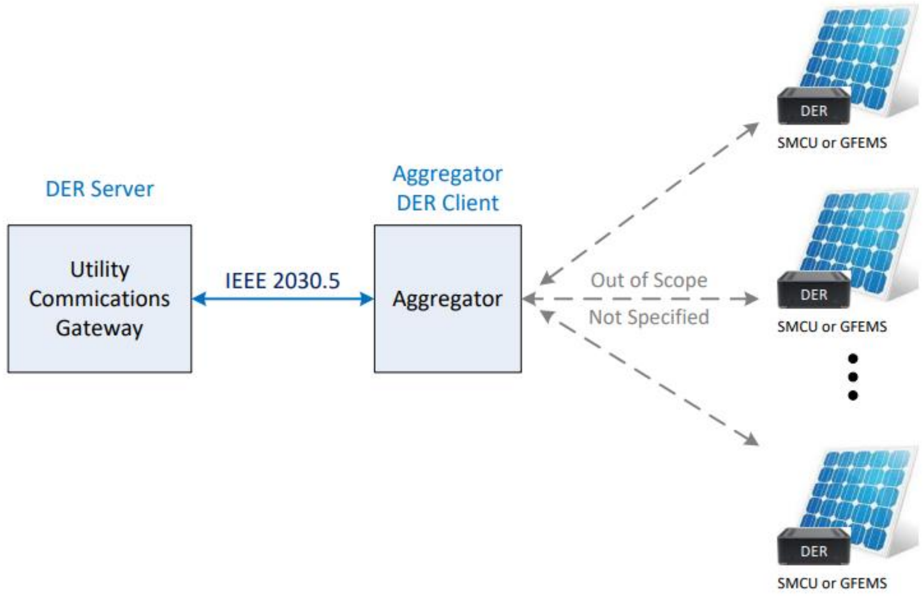
- These International have been developed to allow native interoperability between bidirectional EVs, EVSE and energy management systems, regardless of type of connector used (CCS, NACS, or CHAdeMO).

The availability of these standards offers a clear upgrade path for EV and EVSE manufacturers wishing to support bidirectional charging for existing EV models as well as for future models to be released.

CERTIFICATIONS AND COMMUNICATOIN PROTOCOLS

IEEE 2030.5 CSIP protocol:

- mandated by California Rule 21
- allows grid operators to send low-level operating setpoints or constraints (e.g., apply a certain power factor correction) to grid-connected V2G inverters to maintain network stability.



Open ADR protocol:

- Developed so that flexibility service providers and "aggregators" are able to "bundle" many EV's into a VPP (virtual power plant)
- VPP's seamlessly interface with various devices in order to offer aggregated demand response services to ISOs (independent system operators such as CALISO) or DSOs (distribution system operators).

VIRTUAL POWER PLANTS

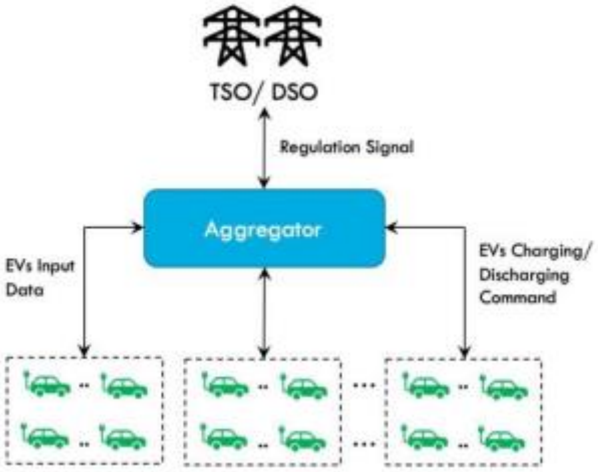
- Virtual Power Plants allow aggregation of multiple smaller distributed energy assets into large "pools" of energy storage reserves.
- Virtual Power Plants help eliminate the need for dirty fossil-fuel "Peaker Plants"
- "Scaling up" assets is the key!

“Scaling Up” = CAPACITY!

- Ca. currently has 1.5 million EV’S
- 1.5 mm x 60 kWh = 90,000 MWH = 225 X the LARGEST GRID SCALE ENERGY STORAGE IN EXISTANCE
- 12.5 million EV’s anticipated by 2035 = 750,000 MWH =

1,875 X LARGEST GRID SCALE ENERGY STORAGE IN EXISTANCE


Battery racks provided by LG Energy Solution sit in former turbine halls at Moss Landing Energy Storage Facility, California. Image: LG Energy Solution.



DEMAND RESPONSE

- Ca's highest peak demand on Sept. 6th 2022 was;
  51,426 MW

- 12.5 mm EV's @ 10 kw = **125,000 MW**

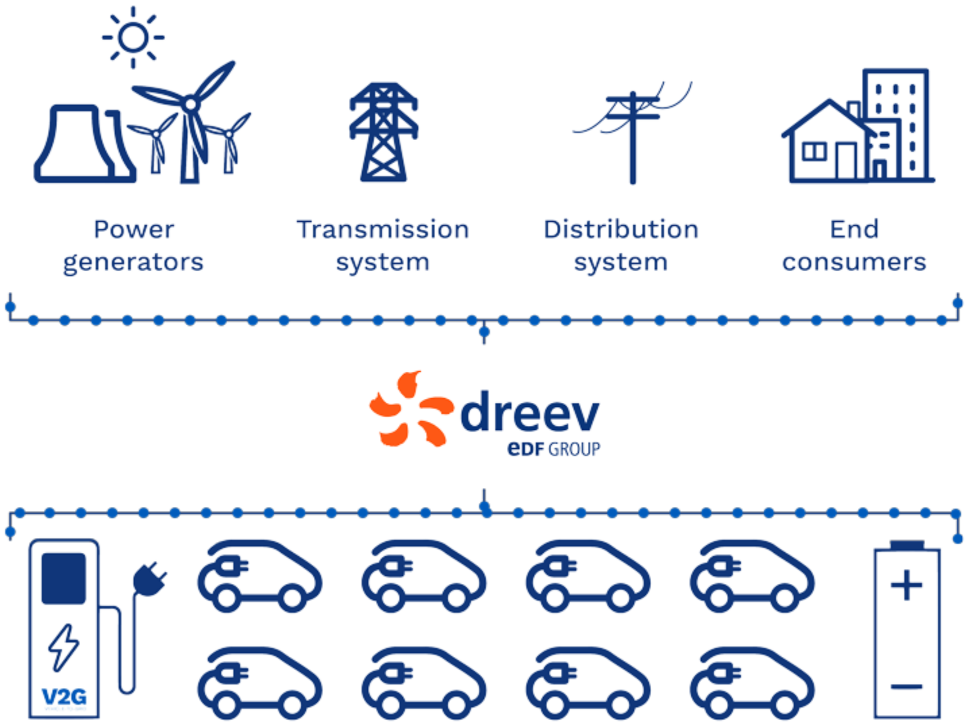
- V2G represents an ever expanding capacity for demand response





V2G ENABLING FACTORS

- BIDIRECTIONAL EV's ✓
- BIDIRECTIONAL TECHNOLOGIES ✓
- BIDIRECTIONAL GRID COMMUNICATION PROTOCOLS ✓
- FIRE CODES AND SAFETY STANDARDS ✓
- ACCESS TO VPP MARKETS - ??
- BUILDING CODES FOR PREWIRING - ??



ELECTRIFICATION AND COMMUNITY RESILIEINCE (ECR) DOCUMENT

- DEVELOPED WITH INDUSTRY EXPERTS IN ELECTRIFICATION, ESS, AND BIDIRECTIONAL EV TECHNOLOGIES
  - EPRI
  - 2050 PARTNERS
  - DCBEL
  - NUVVE
  - CharIN

ELECTRIFICATION + ENERGY STORAGE + BIDIRECTIONAL EV READY

Electrification & Community Resilience (ECR)
design standard and economic analysis

Every community can benefit from resilience. Nanogrids and microgrids are a key part of a comprehensive resilience solution. Whether facing a wildfire, earthquake, or coordinated threat, nanogrids and microgrids enable continued access to energy by islanding from the utility grid during a grid outage. Adding V2X capabilities enhances resilience even further, and enables use of EV's as mobile energy assets. EV's as mobile batteries can travel to "recharge" if necessary, then bring that energy wherever it is needed.

Below are site definitions to support applying the recommendations in the next section to various buildings and communities. Both nanogrid / microgrid types defined below electrify all on-site energy loads; incorporate high levels of local distributed energy resources (DER) such as solar, energy storage, and load management; and provide resilience. Additionally, these solutions are cost-effective and can provide benefits to the grid and to other grid users by reducing the cost of grid operations and obviating the need for new grid infrastructure investments.

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<tr><th colspan="2">Nanogrid/Microgrid-ready site definitions</th></tr>
<tr><td colspan="2">Nanogrids and Microgrids are capable of disconnecting from the grid in the event of a grid disruption; this functionality is known as "islanding." Renewable energy nano/microgrids must be equipped with on-site renewable generation (e.g., solar), energy storage (e.g., batteries), and a microgrid controller. Microgrids may include smart electric appliances and smart bidirectional electric vehicle (EV) chargers, which provide additional functionality. The microgrid controller monitors, communicates with, and controls the DER and smart appliances; the microgrid controller must also be able to communicate with the grid operator, if demand response enabled.
• Nanogrid-Type 1: Single customer — Loads and generation are behind a single customer's utility meter. Islanding occurs behind the customer's utility meter.
   o Facility examples: Single-family home, condominium, apartment, office building, clinic.
• Microgrid-Type 2: Community Microgrid — Loads and generation are behind or in front of multiple customers' utility meters but are all downstream of a distribution substation. Islanding occurs in front of the customers' utility meters (such as at the distribution feeder) and includes multiple utility customers, including Type 1 microgrids.
   o Facility examples: Multi-family housing with separate metering, housing subdivision, civic center with multiple buildings, retail complex, hospital complex.
• Critical loads: When a microgrid is operating in island mode, load shedding can extend throughout an outage, through which a microgrid can maintain power continuity. Tier 1 loads are life-saving critical loads, Tier 2 loads are priority but not critical, and Tier 3 loads are the remainder of the load.</td></tr>
<tr><th>Normal operations</th><th>Emergency operations</th></tr>
<tr><td>On-site DER deliver energy to all loads and may export excess energy generation to the grid, depending on interconnection and tariff. Smart electric appliances can perform demand response, and smart bidirectional EV chargers can perform demand response and export to the grid by turning on or off according to grid needs; resources are dispatched based on signals from grid operators. Energy storage enables self-powering and/or load shifting to off-peak times. Utilities, Community Choice Aggregators (CCAs), or Type 1 on-site users maintain control over site operations in accordance with operations contracts.
Benefits:
• Reduced customer utility bills during peak times, with both energy and demand charges reduced
• Renewable energy for the broader grid
• GHG reductions of up to 69% or more*
• Revenue from export and aggregation of DERs</td><td>During a grid outage, the microgrid disconnects from the grid and operates in island mode. At minimum, DER serve predefined Tier 1 critical loads. Tier 2 and 3 non-critical loads are powered based on real-time energy generation and storage availability. Increasing energy storage duration increases backup power capabilities.

Type 1: On-site resources serve on-site loads only.
Type 2: On-site resources may be used to power off-site loads, and vice versa. Community-wide Tier 1 loads are prioritized.

Benefits:
• Increased resilience
• Energy and transportation security
• Ability to share energy throughout V2X systems</td></tr>
<tr><td colspan="2">*Electricity, residential, commercial, and transportation comprise 69% of state GHG emissions, according to the 2018 C-ARB report</td></tr>
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These ECR recommendations apply to residential structures. Dcbel is working with industry experts to develop similar guidelines for commercial facilities.

Residential nanogrid properties and microgrids responding to emissions reduction targets should be all-electric. All-electric appliances provide increased value for homes because, unlike appliances that rely on gas, they can all be powered by an emission free solar+storage microgrid. If all-electric design is not currently possible for any reason, designs should at minimum include the electrical service features described below to facilitate future full electrification and on-site solar generation.

These recommendations may vary by building and by location; consult your electrician, electrical engineer, and local codes for site-specific recommendations and requirements. This is designed to be a living document that is adaptable and changeable as technologies advance and new technologies arise.

Wiring:
Install the following dedicated circuits and receptacles for all-electric appliances in single-family dwellings (SFDs):

- 200 amp min. Main electrical panel sized for all existing and future loads, including solar, ESS, and V2X
- Grid-connected heat pump water heater (15-30 amp, 240V)
- Heat pump clothes dryer (30 amp, 240V)
- Induction electric range (50 amp, 240V)
- Grid-connected heat pump space conditioner (heater and air conditioner) (30-60 amp, 240V)
- Grid-connected EV charger (40-80 amp, 240V)
- **For V2X - Two 40 amp sized wires/circuits (or conduit) from the EV Charger location to the main panel (or backed up loads panel) (Recommend placing the main (or backed up) panel in Garage next to EV Charger location)**
- **Place a 120V circuit and receptacle next to bidirectional Charger/Inverter for UPS / blackstart**
- **175 Amp 240V breaker in main panel, main wire to ATS location, and then to sub panel(s).**
- **Add signage for component locations for V2X and ESS prewired locations; "ATS", "Auto Transformer", "Battery", V2X "charger/inverter", etc. so that these locations are able to accommodate the components at a later date.**

Solar-ready electrical service for future solar array:

- Main service panel (MSP) rated 225 amps (allows for a 200-amp main breaker plus bus bar capacity for a solar array of up to 70 amps) **(For V2X: Place main service panel on exterior of garage near EV charger and solar inverter, and subpanel near V2X charger/inverter)**
- add or plan location for Backed up loads subpanel,) **OR** "smart" main panel with programmable breakers (e.g., Eaton, Leviton, Schneider) **Alternative: place subpanels and wiring to accomodate Lumin Smart Panel. Leave room in the main panel for a monitoring/communication device if possible.**
- Double-pole circuit breaker
- Metallic conduit for future solar installation (from roof to inverter location/panelboard)

Energy Storage System (ESS) ready:

- Designate area for ESS; size of this battery area will depend on required/desired loads to be served by system (i.e., critical loads for backup only vs. full operability in grid outage). Locate battery out of vehicular path of travel, or provide bollards for vehicular impact protection. Add signage if prewiring only.
- Main electrical line "loop" or junction box to ATS location, between electrical service meter and main panel / subpanel(s), and at designated battery location(s).
- Loop or junction box at backed up loads subpanel power lead to designated ESS location
- Separate subpanel for loads that require backup (can be added during remodel) **OR** load shedding main panel with programmable breakers, or programmable breakers for existing panel (e.g., Eaton, Leviton, Schneider) **(Alternative: place subpanels and wiring to accomodate Lumin Smart Panel)**
- Allow capacity in subpanel(s) for emergency circuits to serve critical loads (e.g., refrigerator, HVAC, water heater, microwave) and desired outlets with backup power during grid outages.
- Ethernet line from main router to ESS location, **to inverter, from main panel to bidirectional EV charger location, and from bidirectional charger/inverter to ESS location**
- **ESS, main and sub panels, and bidirectional EV Charger/inverter should be as close together as possible**
- **120V wiring over battery location for heat detector, which is interconnected to fire alarm bell.**
- **When planning component placement, consider future access issue for repair, etc.**

Additional recommended features for interconnection and communication:

- Communications conduit for demand response–capable electric appliances
- Connectivity; Open ADR, CTA 2045 for appliances, IEEE 2030.5 for energy storage **and V2X**

Estimated costs for prewiring electric-ready homes

- **(Nanogrid / V2X Ready costs are on following page)**
- Below is a rough cost estimate for the parts and labor required to prewire typical floor plans offered by Santa Rosa contractors in the North Bay, California, rebuild area.
- The prewiring costs for appliances vary depending on the architect's design. A primary 200-amp electrical panel is typically positioned where power reaches the home, often on the outside of the garage nearest the street. In small homes, runs of wire may go directly to receptacles to serve major appliances. In larger homes, 100-amp subpanels are often installed in easily accessible indoor locations, such as the laundry room, to serve large nearby appliances such as the dryer, water heater, electric stove, or spa.
- Wiring may not have to be placed in walls but may go more directly to appliances through crawl spaces, attics, floor joists, and other spaces deemed non-occupied areas. Wire sizes for each appliance are indicated. Length and cost should be calculated according to local costs and the house plan.

Item	Wire size	Length***	$/ft	Total
Stove	6/3 Romex	50 ft		$
Water heater	6/3 Romex*	35 ft		$
Dryer	6/3 Romex	35 ft		$
Heat pump	6/4 Romex**	35 ft		$
Receptacles (4 @ $5 ea) Two 40 amp wire runs (for V2X)	 6/3 Romex	 10 ft		$ $
Subtotal for materials				**$**
2-3 hours labor for installation******				**$**
ESTIMATED TYPICAL TOTAL COST				**$**

- * Water heater circuit will be required by 2019 title 24 code.
- ** Heat pump circuit can replace air conditioner unit circuit, which is often offered in new homes.
- *** Typical distance from the garage (where the main electrical panel is typically placed) to the appliance
- **** Some labor may be unnecessary due to changing code requirements for pre-wiring.
- Costs will vary depending on the position of the electrical panel, appliance locations, home size, etc. Water heaters, dryers, and external heat pump compressors are typically located in or near the garage.

Estimated costs for additional features to make homes Nanogrid/V2X Ready

ITEM	APPX COST
Energy Storage System (Nanogrid) ready:	
• Designated area for ESS; size of this area will depend on required/desired loads to be served by system (i.e., critical loads for backup only vs. full operability in grid outage); keep near "smart" main and/or backup loads subpanel, out of vehicular path of travel	$
• Main electrical line "loop" (8 feet) to ESS location, between electrical service meter and main panel or subpanel; keep ESS near main and subpanel (This is unnecessary is ESS is placed next to main electrical panel	$
• Separate subpanel for loads that require backup (can be added during remodel); keep next to main panel and ESS	$
- **OR** -	
Capacity in subpanel or "smart" main panel (Eaton, Leviton, Schneider or similar) for emergency circuits to serve critical loads (e.g., refrigerator, HVAC, water heating, microwave, lights and outlets with ESS battery power during grid outages, including bidirectional EV-ready) **OR, use Lumin Smart Panel**	$
• Ethernet communications line from main router to ESS location (60')	$
• Ethernet line for communication from solar inverter(s) to ESS location	$
• Upgrade to certified smart inverter for islanding, plus ESS export to grid (optional); (this is often included in the ESS package price and user interface)	$
V2X bi-directional EV charge/inverter ready	
• Two 40 amp wire runs from V2X charger/inverter to subpanel	$
• Ethernet communications line from main service panel to bidirectional charger location	$
Nanogrid + V2X Ready total	$

COMMUNITY RESILIEINCE (CR) DOCUMENT – (ENERGY STORAGE + BIDIRECTIONAL READY)

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- **120V wiring over battery location for heat detector, which is interconnected to fire alarm bell.**
- **When planning component placement, consider future access issue for repair, etc.**

Additional recommended features for interconnection and communication:

- Communications conduit for demand response–capable electric appliances
- Connectivity; Open ADR, CTA 2045 for appliances, IEEE 2030.5 for energy storage **and V2X**

Estimated costs for additional features to make homes Nanogrid/V2X Ready

ITEM	APPX COST

Energy Storage System (Nanogrid) ready:

- Designated area for ESS; size of this area will depend on required/desired loads to be served by system (i.e., critical loads for backup only vs. full operability in grid outage); keep near "smart" main and/or backup loads subpanel, out of vehicular path of travel — $ ___
- Main electrical line "loop" (8 feet) to ESS location, between electrical service meter and main panel or subpanel; keep ESS near main and subpanel (This is unnecessary is ESS is placed next to main electrical panel — $ ___
- Separate subpanel for loads that require backup (can be added during remodel); keep next to main panel and ESS — $ ___

  - OR -

  Capacity in subpanel or "smart" main panel (Eaton, Leviton, Schneider or similar) for emergency circuits to serve critical loads (e.g., refrigerator, HVAC, water heating, microwave, lights and outlets with ESS battery power during grid outages, including bidirectional EV-ready) **OR, use Lumin Smart Panel** — $ ___
- Ethernet communications line from main router to ESS location (60') — $ ___
- Ethernet line for communication from solar inverter(s) to ESS location — $ ___
- Upgrade to certified smart inverter for islanding, plus ESS export to grid (optional); (this is often included in the ESS package price and user interface) — $ ___

V2X bi-directional EV charge/inverter ready

- Two 40 amp wire runs from V2X charger/inverter to subpanel — $ ___
- Ethernet communications line from main service panel to bidirectional charger location — $ ___

Nanogrid + V2X Ready total — $ ___

KEEPING THE LIGHTS ON IN AN ALL-ELECTRIC FUTURE

THANK YOU
FOR
YOUR TIME !

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